Photo 7-53 A side view of Site 21 midpoint

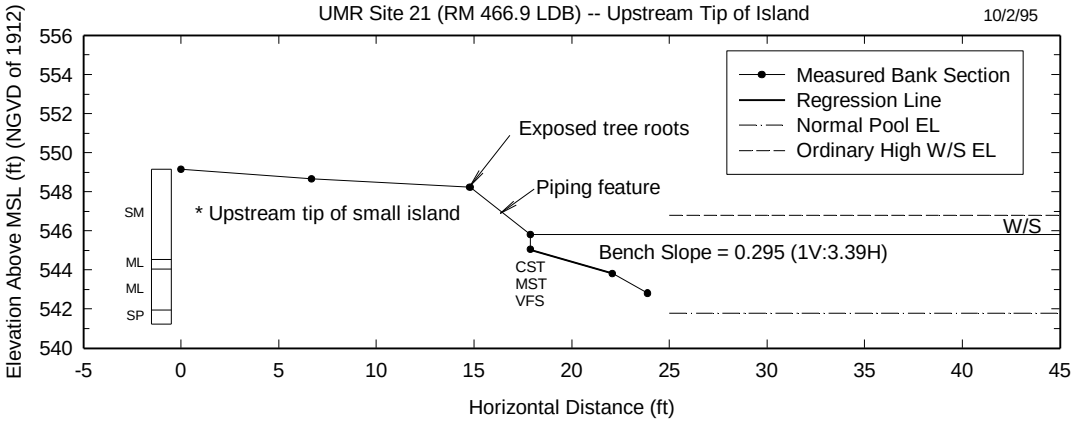

Figure 7-74 Bank section measured at Site 21 upstream tip of island

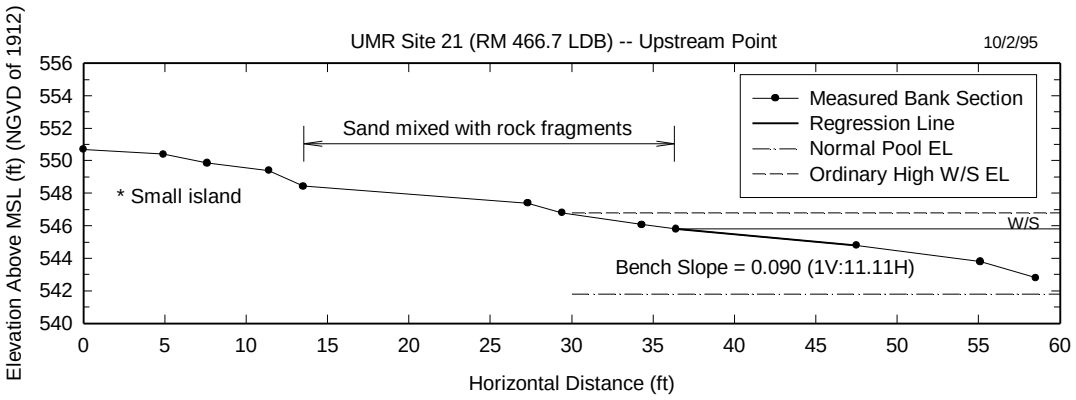

Figure 7-75 Bank section measured at Site 21 upstream point

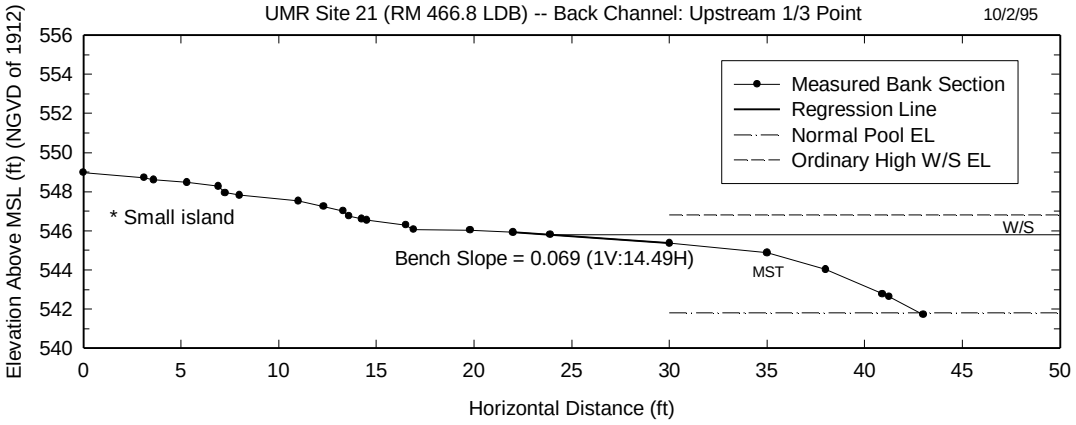

Figure 7-76 Bank section measured at Site 21 back channel upstream 1/3 point

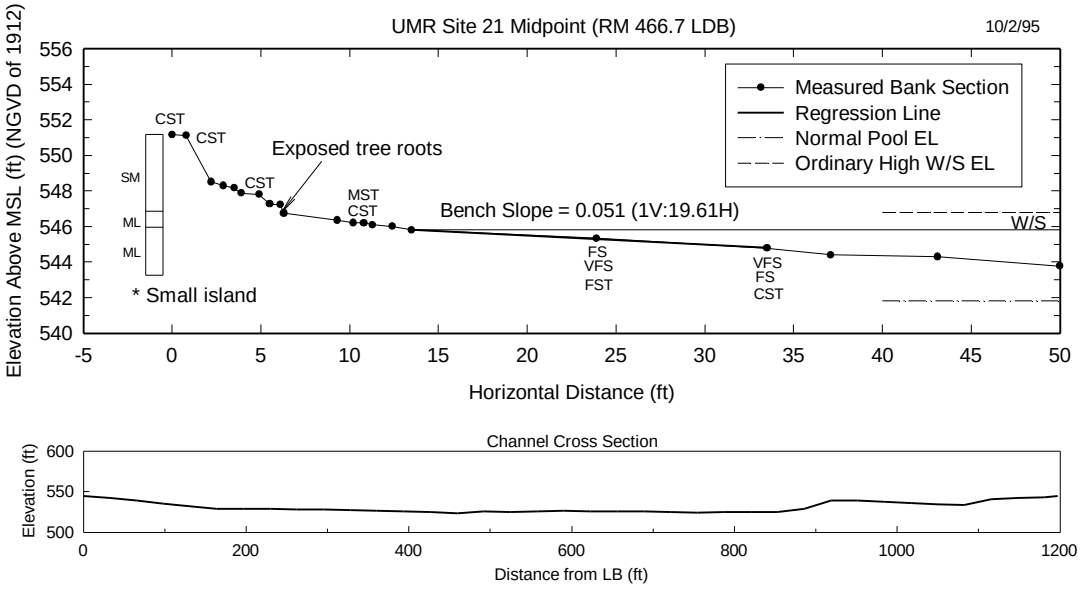

Figure 7-77 Bank section and channel cross section measured at Site 21 midpoint

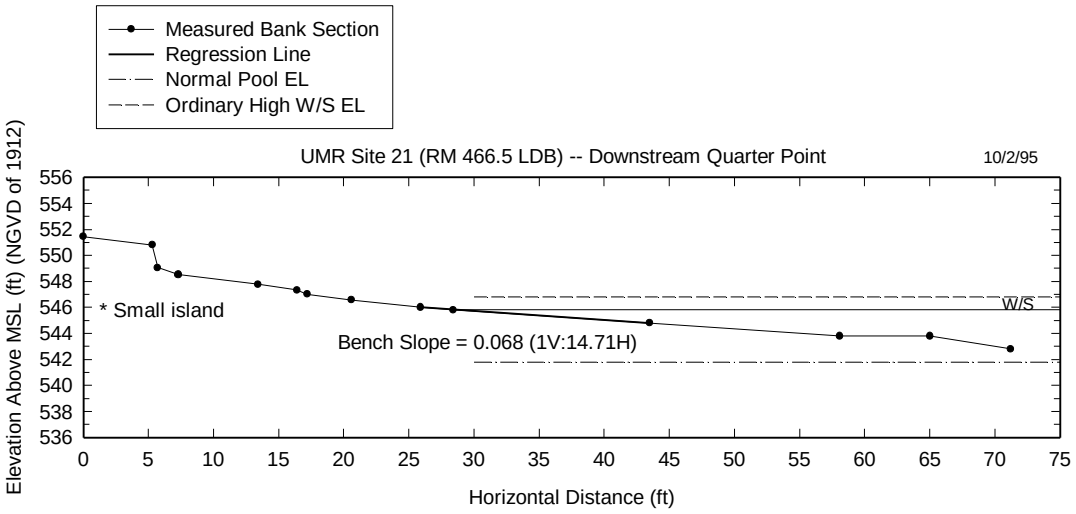

Figure 7-78 Bank section measured at Site 21 downstream quarter point

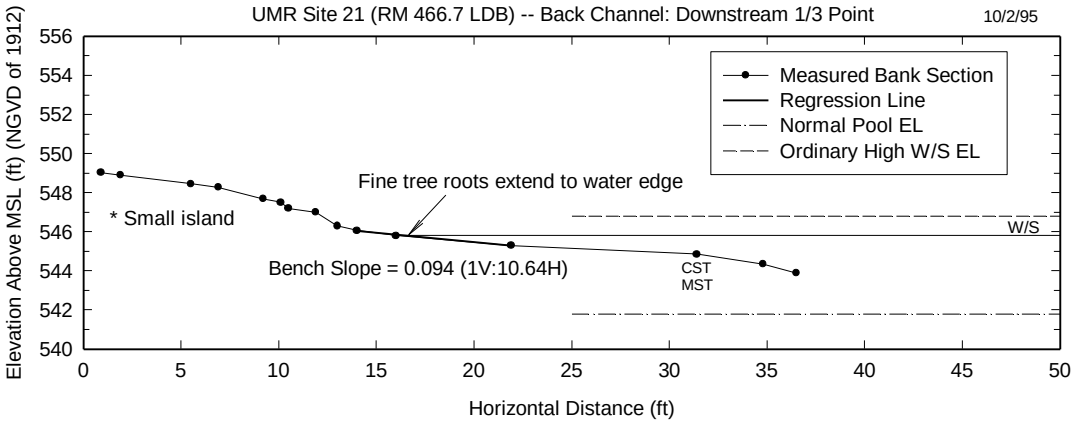

Figure 7-79 Bank section measured at Site 21 back channel downstream 1/3 point

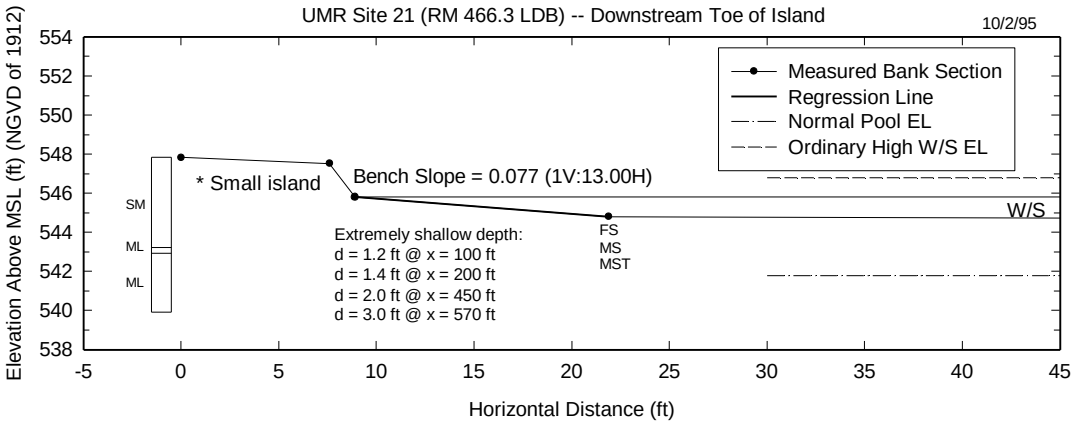

Figure 7-80 Bank section measured at Site 21 downstream toe of island

22. Site 22 at RM 436.4 LDB (Pool 18)

This left-bank erosion site, shown in figure 7-81, is located along a narrow straight river reach opposite Keg Island, only 0.7 mile downstream from Lock & Dam No. 17.

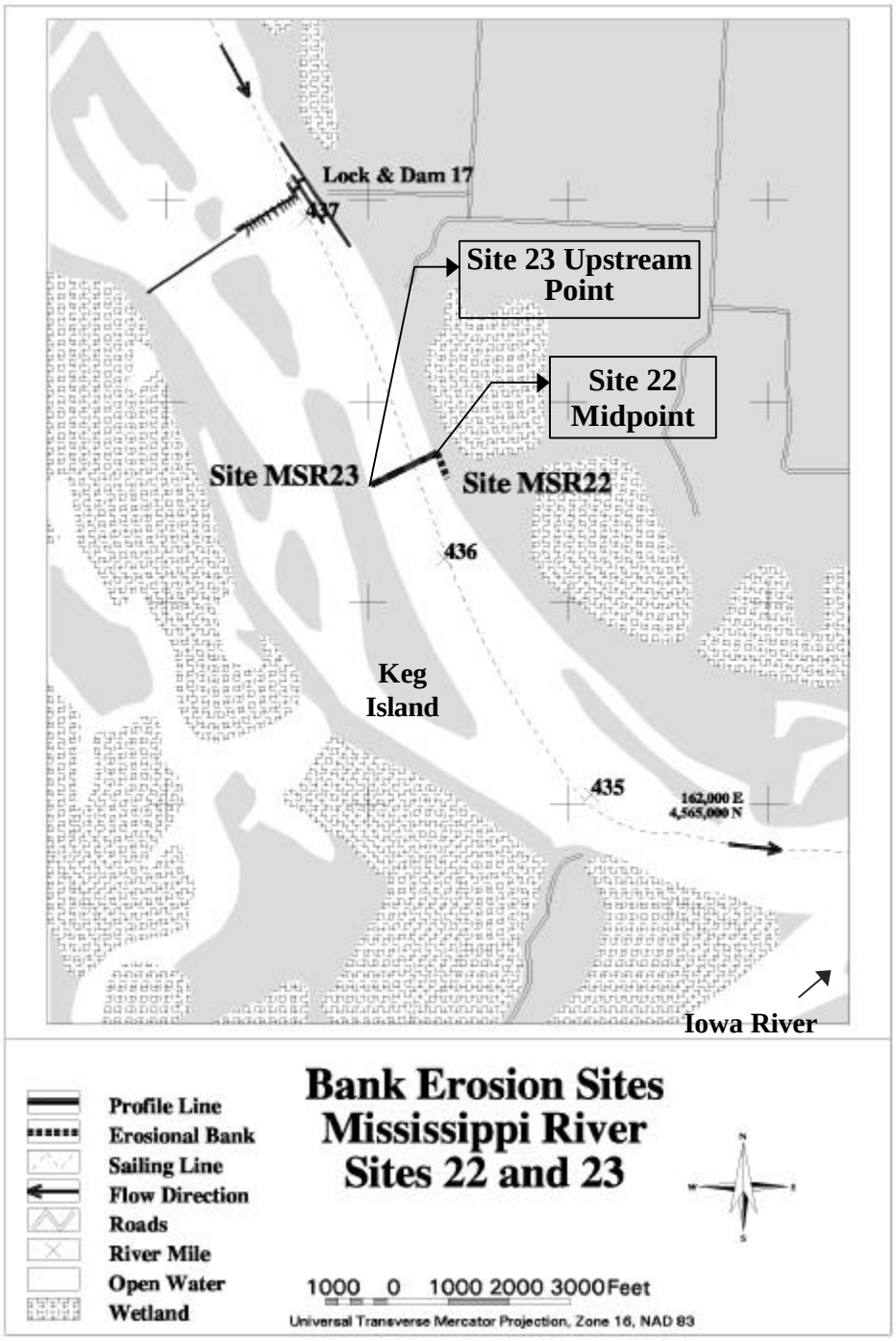

Figure 7-81 A site map showing Mississippi River Sites 22 and 23

Photo 7-54 An upstream view of Site 22 midpoint

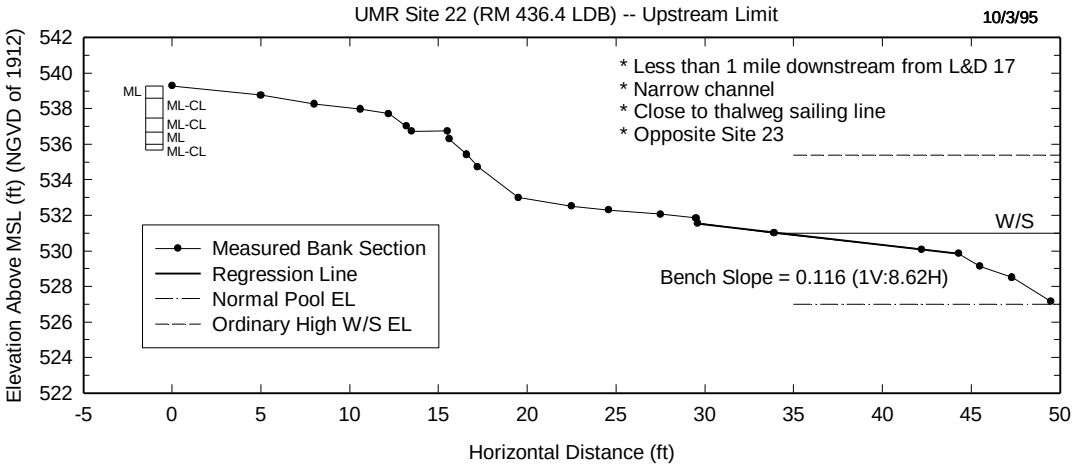

Figure 7-82 Bank section measured at Site 22 upstream limit

An upstream view of the midpoint section is shown in Photo 7-54. Five bank sections were taken at the erosion site: at the upstream limit; the upstream quarter point; the midpoint; the downstream quarter point; and the downstream point. The sections are depicted in figures 7-82 through 7-86. As can be seen in figure 7-84, the channel cross

section is a typical parabolic shape common to straight channels. The bank soils consist of silt (FST-MST) with moderate piping features and subaqueous sediments are silt (MST-CST) and sand (VFS). Site 22 is very close to the thalweg sailing line. Steep subaqueous bank slopes observed along the bank downstream from the midpoint section indicate that this reach is subject to strong currents and vessel-induced prop-wash.

Three sampling tube cores were advanced at this location. One core advanced near the channel margin showed 6.2 ft of historical alluvium over an early to mid-Holocene soil. Two more cores advanced to the east of the constructed levee showed no historical deposits on the surface. The profile showed a late Holocene soil to about 2.6 ft, underlaid by early to mid-Holocene paleosol.

Two additional cores were advanced in the Lock & Dam No. 17 area in September 1996 during an environmental study. These cores showed a profile similar to that at Site 22 with a late Holocene soil burying an older early to mid-Holocene soil. In addition, the investigations during the erosion study recovered pre-historic pottery along the channel margin. Site 22 is located very close to that archaeological site. The older Holocene soils and archaeological site 11MC124 have been eroded.

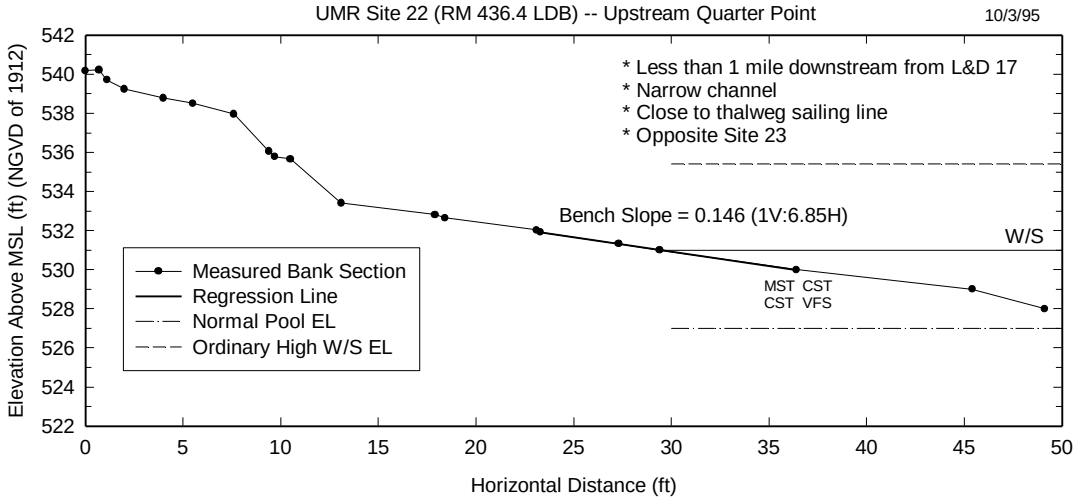

Figure 7-83 Bank section measured at Site 22 upstream quarter point

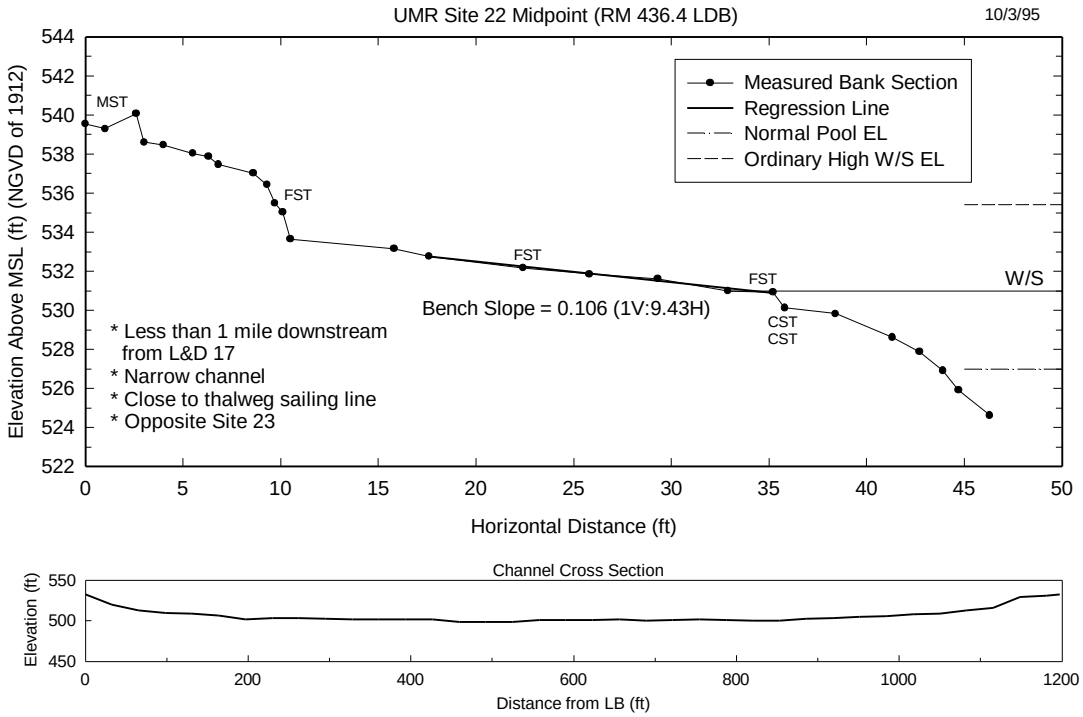

Figure 7-84 Bank section and channel cross section measured at Site 22 midpoint

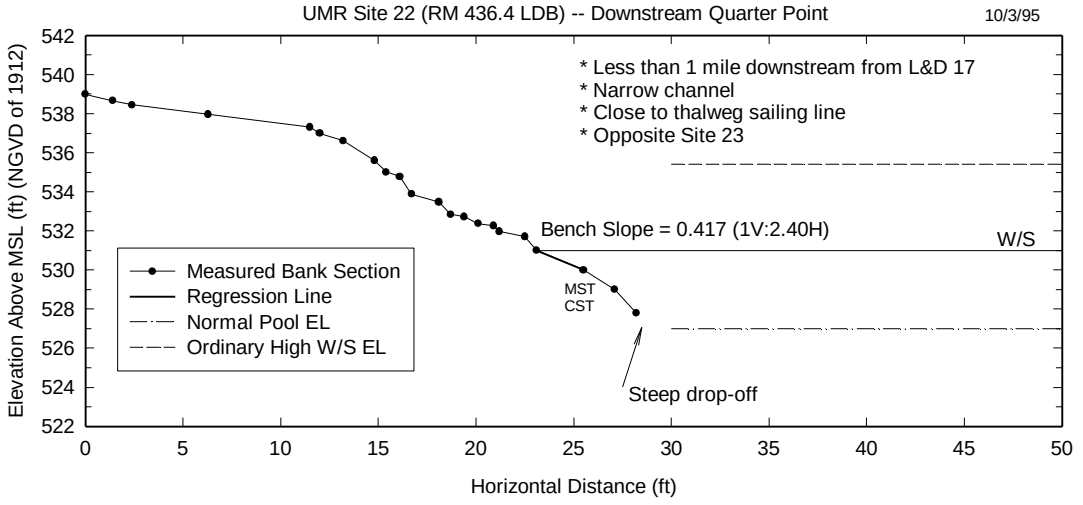

Figure 7-85 Bank section measured at Site 22 downstream quarter point

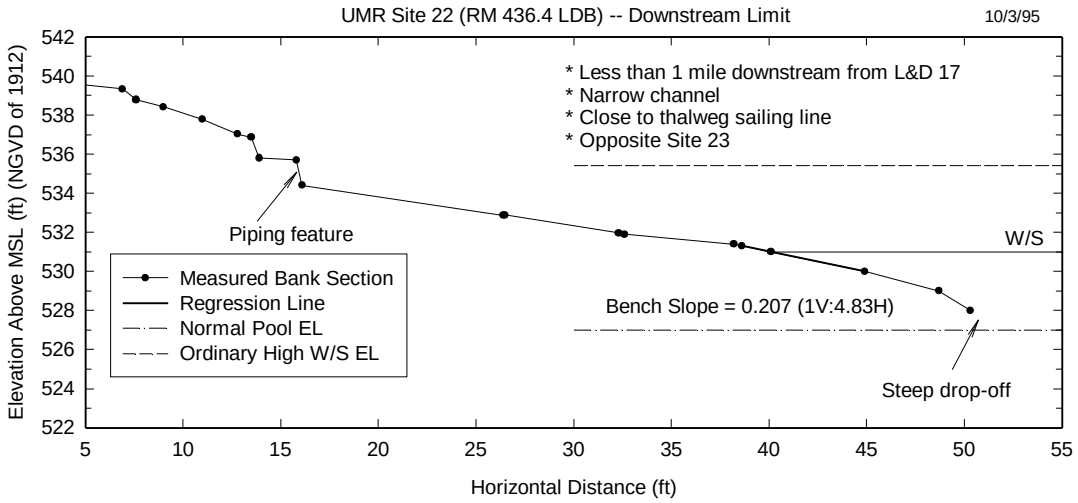

Figure 7-86 Bank section measured at Site 22 downstream limit

Causative factors for bank retreat at this site include flood-flow erosion and slumping during the rapid recession period, wave and flow rework-transport of failed soils and recently deposited sediments, and moderate piping failures. Because of the closeness to the thalweg sailing line, potential exists for wave erosion of failed soils and recently deposited sediments. Type C characterizes Site 22.

23. Site 23 at RM 436.4 RDB (Pool 18)

This right-bank site is located on the upper portion of Keg Island across the channel from Site 22 (see figure 7-81). A downstream view of the upstream site is shown in Photo 7-55. Two bank sections were taken at upstream and downstream points, and they are shown in figures 7-87 and 7-88. No midpoint section was established. The site is located far from the thalweg sailing line. As can be seen in figure 7-87 and Photo 7-55, stone slope-protection failure was observed at the upstream section. The bank soils consist of lensing silt (FST-CST) and some sand (FS) was found on the surface along the water's edge. Subaqueous sediments are silt (MST-CST) at the upstream section, and are silt (MST-CST) and sand (MS) at the downstream section.

The site is a late Holocene island whose surface is capped by historical alluvium. One sampling tube core advanced at the site showed historical alluvium to a depth of 4.9

ft, then contacting native soil. The native soil continued to 5.9 ft in depth, and a second buried soil was found deeper.

Causative factors for bank retreat at this site include flood-flow erosion and recessional piping failures, and wave and flow rework-transport of bench-area failed soils and recently deposited sediments. Site 23 is classified as bank Type C.

Photo 7-55 A downstream view of Site 23 upstream point

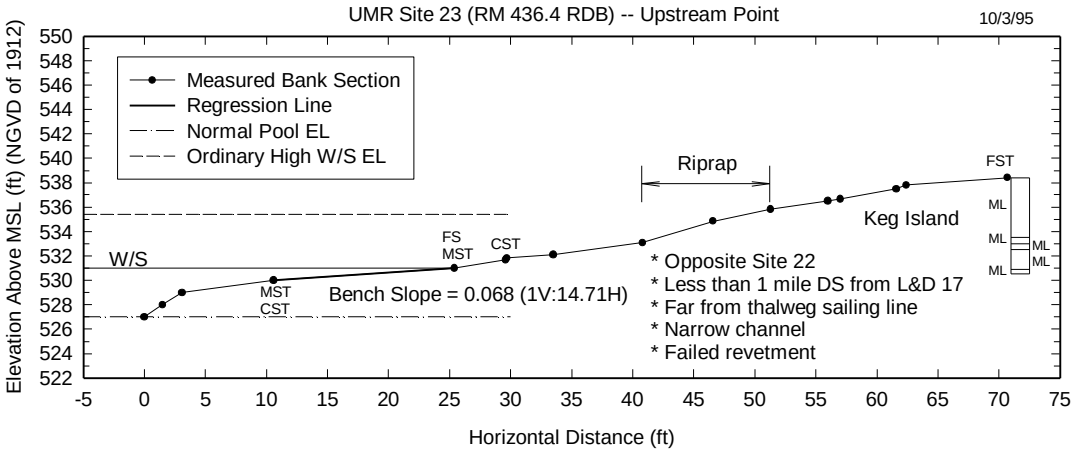

Figure 7-87 Bank section measured at Site 23 upstream point

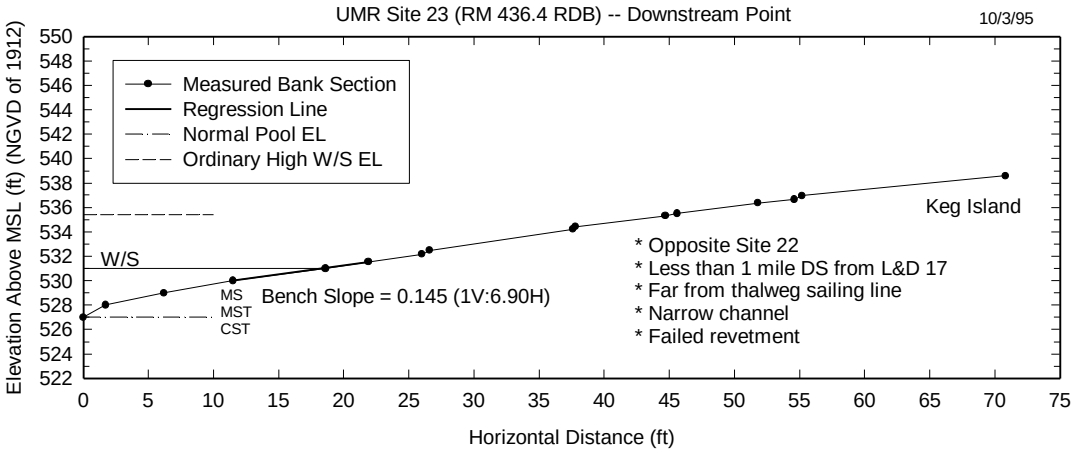

Figure 7-88 Bank section measured at Site 23 downstream point

24. Site 24 at RM 432.2 LDB (Pool 18)

This left-bank site, shown in figure 7-89, is located along the outside of the downstream extent of a sharp bend, only 1.7 miles downstream from the mouth of the Iowa River (RM 434). The site is 4.8 miles downstream from Lock & Dam No. 17, and is close to the thalweg sailing line. An upstream view of this site is shown in Photo 7-56. Three bank sections taken at this site are shown in figures 7-90 through 92. The bank soils consist of sand (FS-CS), and a steep sandy slope rises approximately 40 ft above the berm. This feature is shown in the bank sections.

This erosion site is located along a Wisconsinan outwash terrace. Although no cores were advanced at this site, observations indicate that the main channel is shifting laterally into the outwash terrace.

Causative processes for bank retreat at this site include flood erosion and recessional failures, and wave and flow rework-transport of bench-area failed soils and recently deposited sediments. Because the bank soils are primarily fine sand, wave erosion is extensive. This site is characterized by bank Type F.

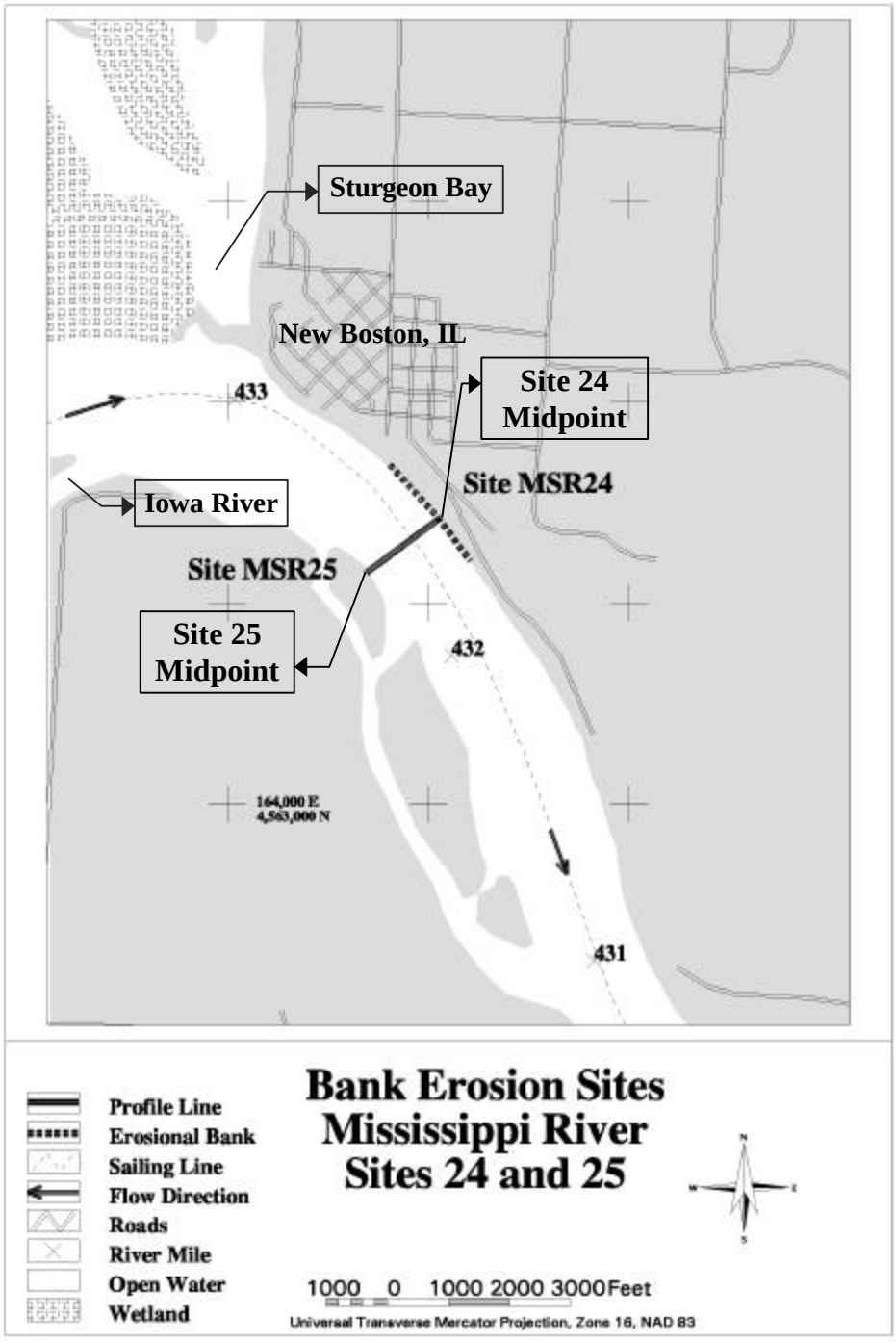

Figure 7-89 A site map for Mississippi River Sites 24 and 25

Photo 7-56 An upstream view of Site 24 midpoint

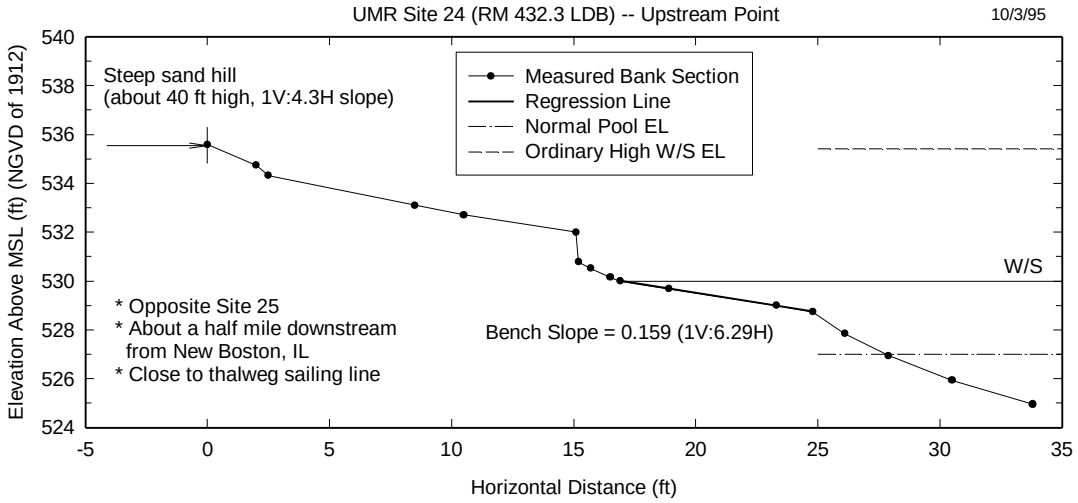

Figure 7-90 Bank section measured at Site 24 upstream point

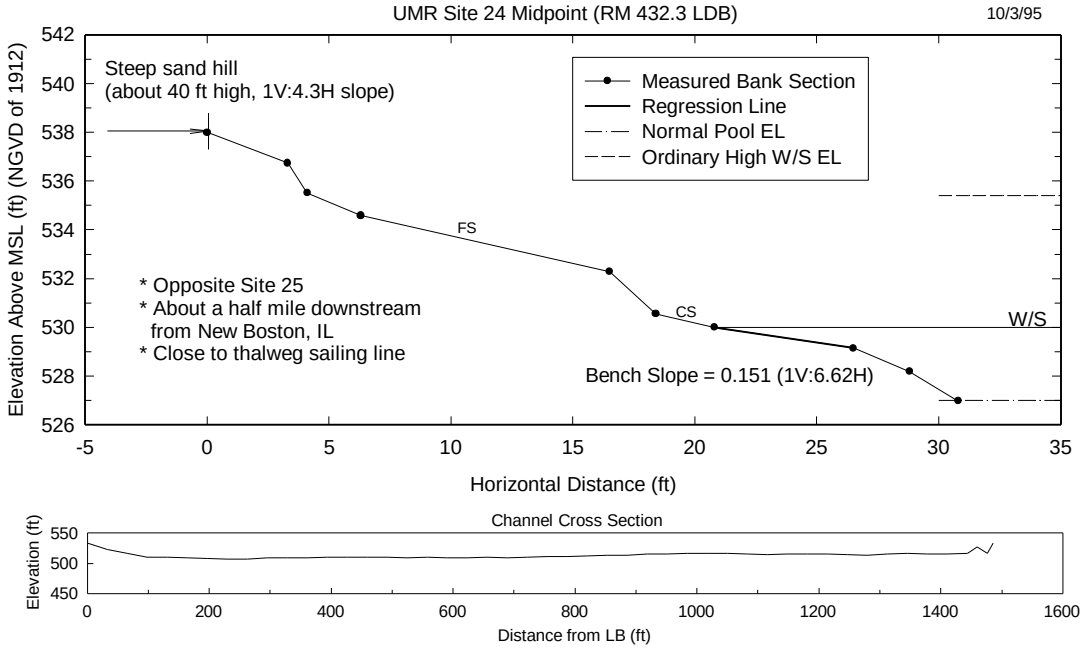

Figure 7-91 Bank section and channel cross section measured at Site 24 midpoint

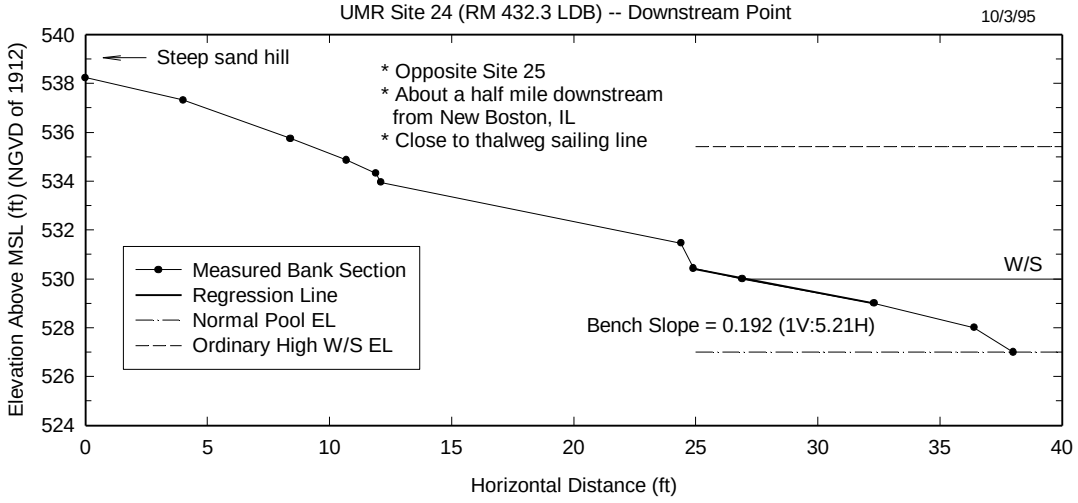

Figure 7-92 Bank section measured at Site 24 downstream point

25. Site 25 at RM 432.2 RDB (Pool 18)

This right-bank island site is located opposite Site 24. An oblique view of this site is shown in Photo 7-57. One bank section taken is shown in figure 7-93. The bank soils are primarily silt (VFST-MST), and subaqueous soil is silt (MST) and sand (FS).

One sampling tube advanced at the site showed thickly bedded historical alluvium throughout the 8.0 ft depth of advance. Erosion at this site is removing stored historical deposits.

The island is covered by a recent sand deposit, about 3 ft deep, apparently from the Great Flood of '93. Causative factors for bank retreat at this site include flood-flow bank oversteepening and rapid recessional slumping and seepage, piping collapse, and wave and flow rework-transport of failed soils and recently deposited sediment cover within bench areas. The steep subaqueous drop-off is a strong indication of channel erosion at this site, as referenced in figure 7-93. Eroded bank type is a combination of Type C and Type D.

Photo 7-57 A side view of Site 25 midpoint

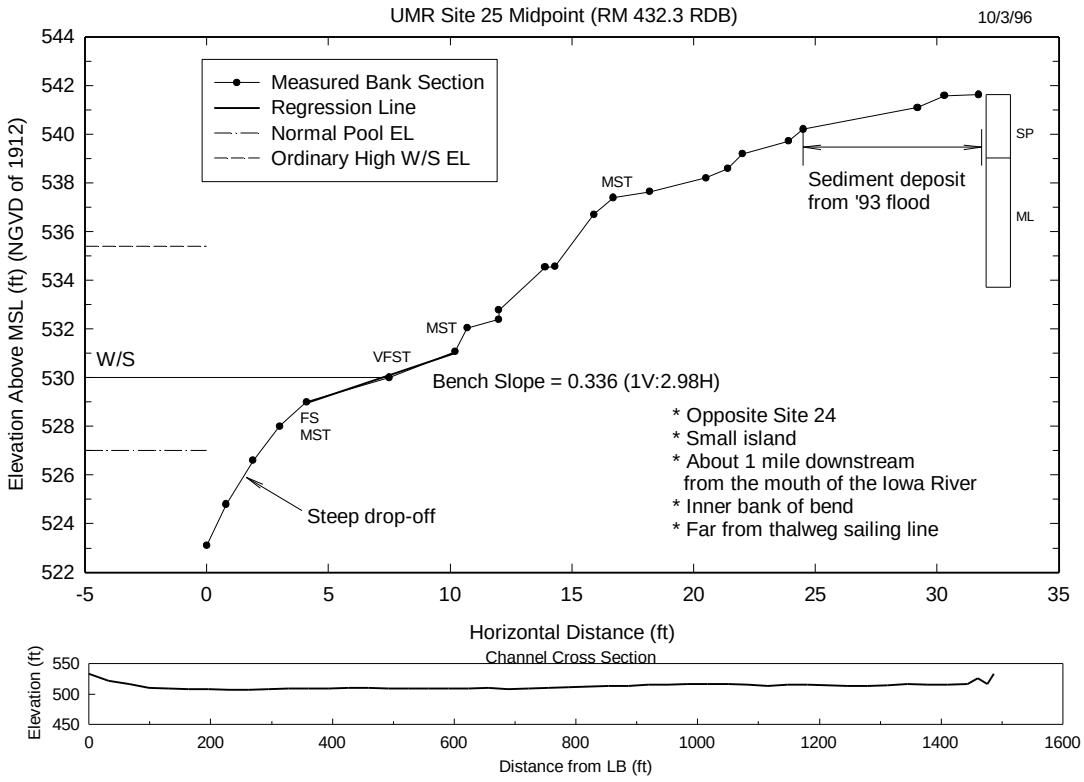

Figure 7-93 Bank section and channel cross section measured at Site 25 midpoint

26. Site 26 at RM 420.0 RDB (Pool 18)

This right-bank site, shown in figure 7-94, is located on Camp Island along a straight channel reach. The site is about 9.5 miles upstream from Lock & Dam No. 18. Camp Island is one of numerous islands formed downstream from the confluence of the Mississippi River and the Iowa River. An upstream view of this site is shown in Photo 7-58. Three bank sections taken at this site are shown in figures 7-95 through 7-97. The bank soils are mainly silt (FST) and sand (MS-CS), and subaqueous bench soil is silt (VFST-MST). As can be seen in the river cross section (figure 7-96), the thalweg is developing along this island. Severe in-channel erosional bank oversteepening is indicated by the steep subaqueous bank slope.

Two sampling tube cores taken at the midpoint section showed that the island is capped by historical alluvium and then dredged spoil up to 8 ft thick. A wetland filled

with historical alluvium was found near the center of the island. Erosion at this site is removing the stored historical deposits.

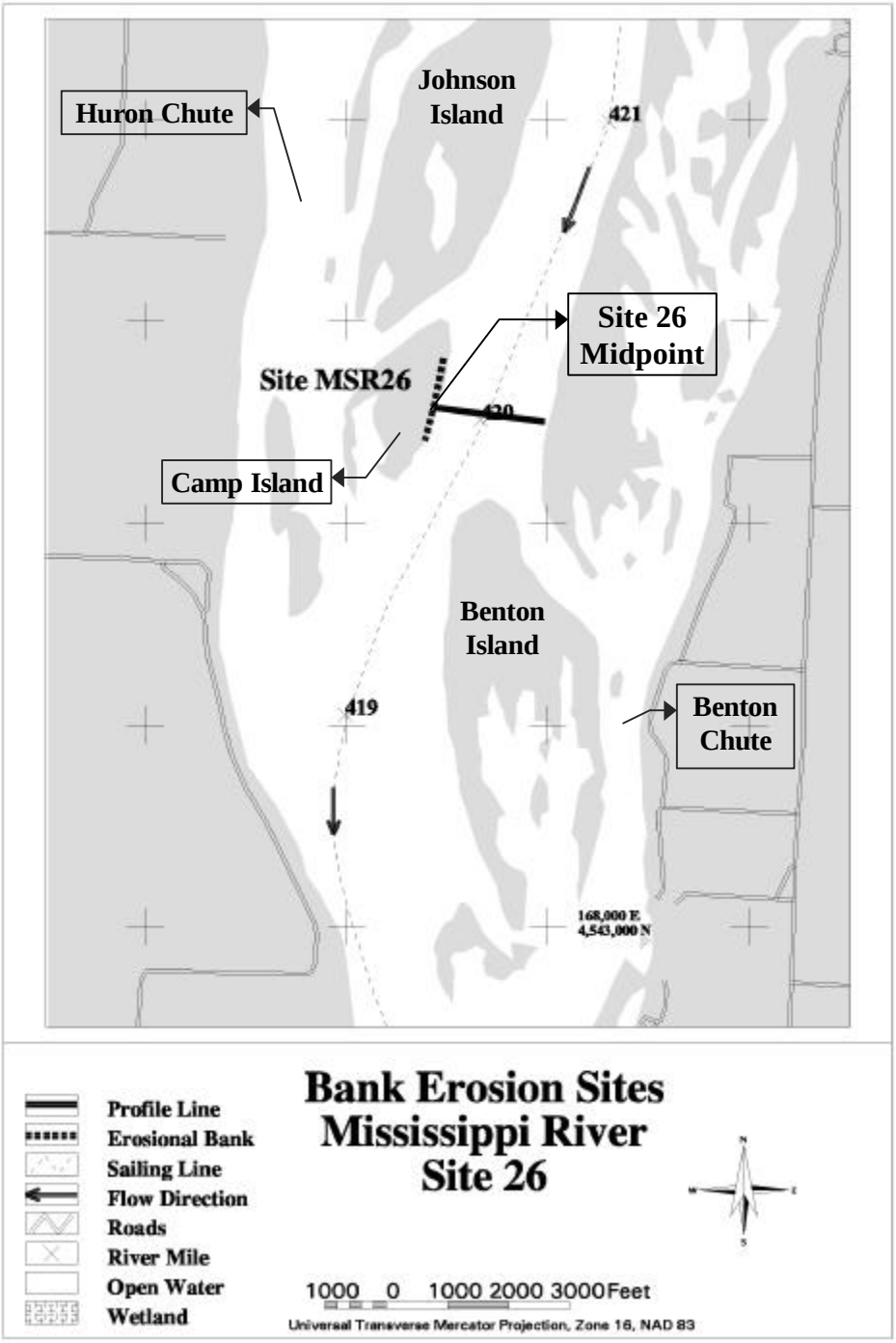

Figure 7-94 A site map showing Mississippi River Site 26

Photo 7-58 An upstream view of Site 26 midpoint

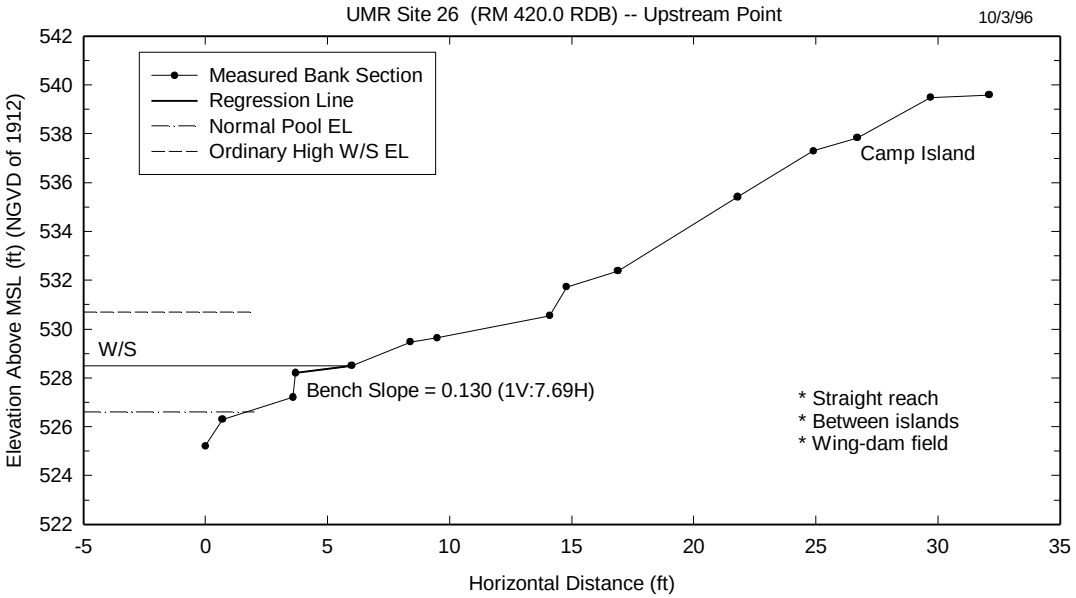

Figure 7-95 Bank section measured at Site 26 upstream point

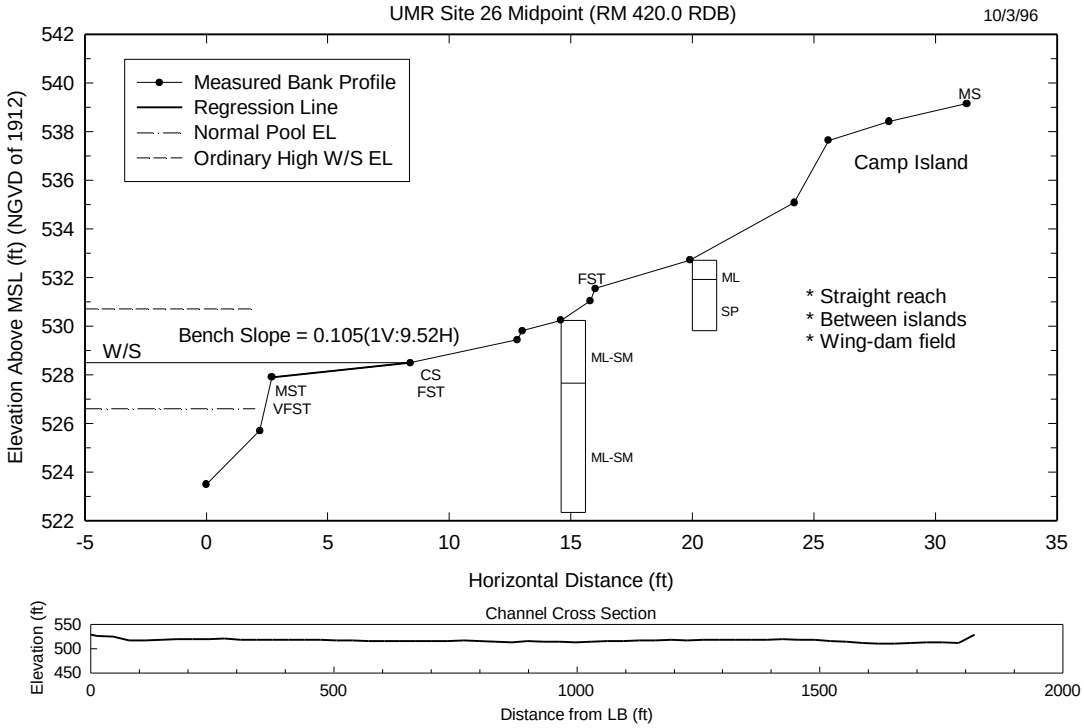

Figure 7-96 Bank section and channel cross section s measured at Site 26 midpoint

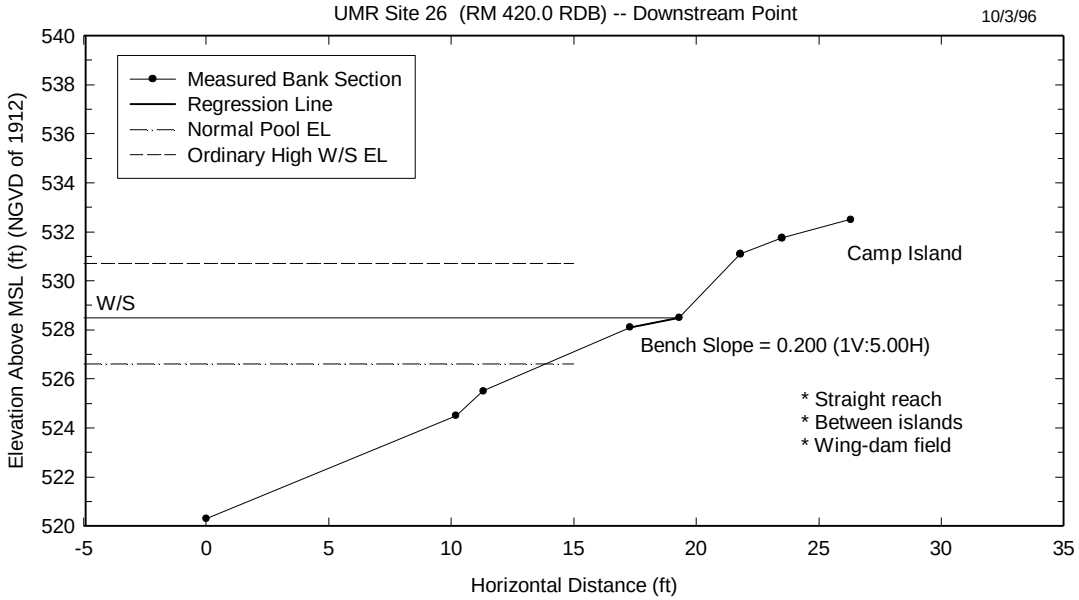

Figure 7-97 Bank section measured at Site 26 downstream point

Causative factors for bank retreat at this site include flood-flow erosion and recessional slumping of oversteepened banks and piping-related collapse with seepage, and wave erosion within bench areas affecting rework-transport of failed bank soils and recently deposited sediments. Because of the closeness to the thalweg and silty bank soils, wave erosion is more extensive at this site. A combination of bank Type E and Type F characterizes this site.

27. Site 27 at RM 360.0 RDB (Pool 20)

This right-bank site, shown in figure 7-98, is located directly across from Warsaw, Missouri, 4.2 miles downstream from Lock & Dam No. 20 and 1.6 miles downstream from the mouth of the Des Moines River. This site is within a rather straight segment within a wing-dam field. Bank retreat since 1984 can be seen in figure 7-98. An upstream view of this site is shown in Photo 7-59 and a close-up view of the scarp is shown in Photo 7-60. Only a midpoint bank section was taken, as shown in figure 7-99. The bank consists of layered silty clay and clayey silt, ranging from coarse clay (CC) to MST. Extensive piping features were observed at the scarp. The thalweg sailing line is remote from the erosion site. The ordinary high-water (25% occurrence frequency) elevation coincides closely with the top elevation of the head scarp. This erosion site includes examples of typical rework-transport bench zones depicted by figure 7-5. A run-out condition affected by blockage from fifteen loaded downstream-bound barges was measured to be about 0.1 ft at the midpoint site.

This erosion site had been mapped as a late Holocene surface; however, the site is characterized by thickly bedded historical alluvium. One sampling tube core showed silty to very fine sandy historical deposits to a depth of at least 8.2 ft. The site included desiccated blocks of failed historical alluvium bank soils at the toe of the scarp and within the bench area.. Desiccated vertical cracks formed deep into the soil profile during the summer of 1995. The cracks result from contraction or shrinkage of smectite expandable silts/clays. As moisture is removed, this creates dry soil conditions. The smectite silts/clays swell during moist periods and close the vertical cracks, which adds the cohesiveness to the medium to fine-grained soils. During the late dry summer of 1995,

river stage levels were lower compared to periods earlier in the year. Soil blocks were observed to be calving and slumping into the river's channel margin. The instability of the banks, indicated by the slumping soil blocks, may be caused by several factors,

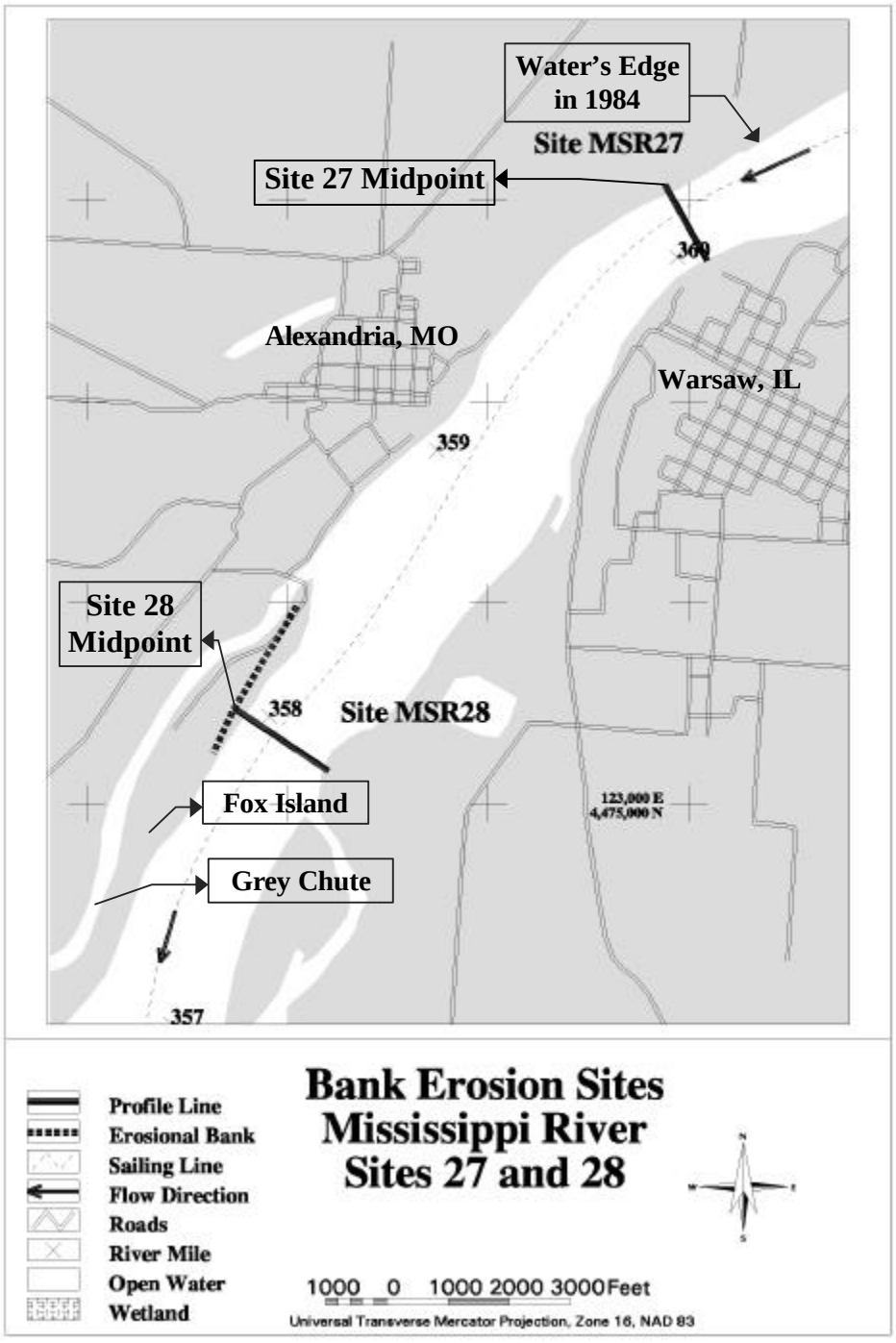

Figure 7-98 A site map showing Mississippi River Sites 27 and 28

Photo 7-59 An upstream view of Site 27 midpoint

Photo 7-60 A close-up view of scarp at Site 27 midpoint

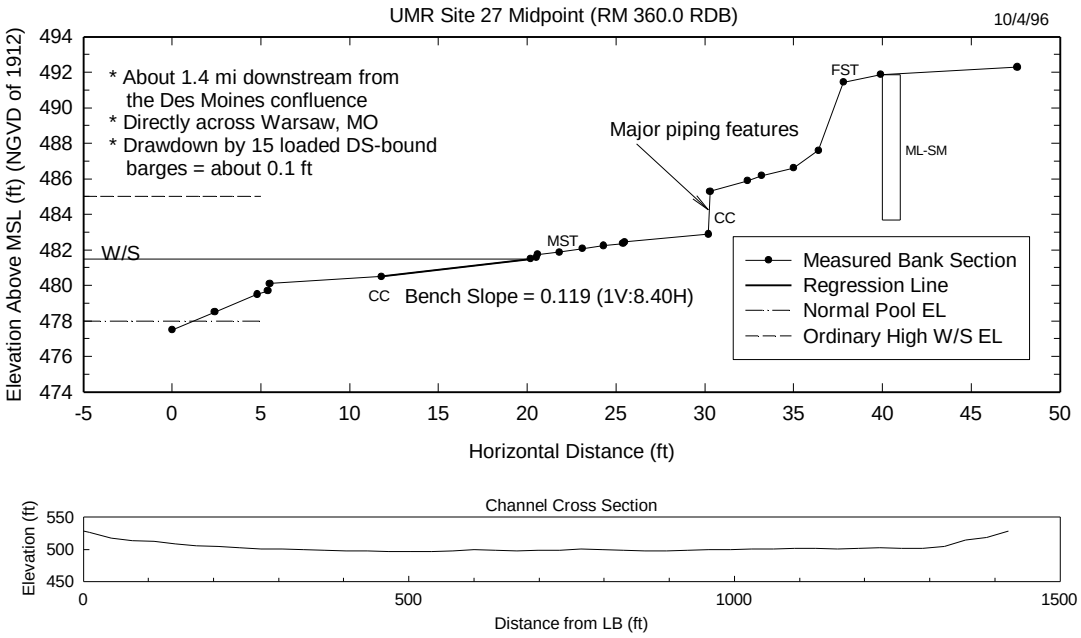

Figure 7-99 Bank section and channel cross section measured at Site 27 midpoint

including (1) weakening of the soil body from vertical fracturing; (2) a lower river stage which caused a steepening of the bank slope; (3) wave actions undermining fine sands along the bank interbedded by silt/fine sand alluvial sequence; (4) head differences between the water table and river level, causing groundwater flow along weaker fine sand seams; and finally, (5) less hydraulic bank support during low water dry periods. Moist conditions and higher river stages, higher water table elevations, and improved soil moisture would tend to provide hydraulic support of the soil body.

Causative factors for bank retreat at this site include flood-flow erosion and recession and piping-initiated slumping, slaking, seepage, and wave and flow rework-transport of failed and slaked bank soils and recently deposited sediments within bench areas. Site 27 is classified as Type A.

28. Site 28 at RM 357.6 RDB (Pool 20)

This right-bank site, shown in figure 7-98, is located on Fox Island in a crossover reach with chronic dredging problems, approximately 6.6 miles downstream from Lock & Dam No. 19. Significant bank retreat since 1984 is evident in figure 7-98. Photo 7-61

Photo 7-61 An upstream view of Site 28 midpoint

Photo 7-62 A close-up view of scarp at Site 28 midpoint

Photo 7-63 Vertical cracks and massive block failures at Site 28 midpoint

Photo 7-64 Piping features and vertical cracks seen at Site 28 midpoint

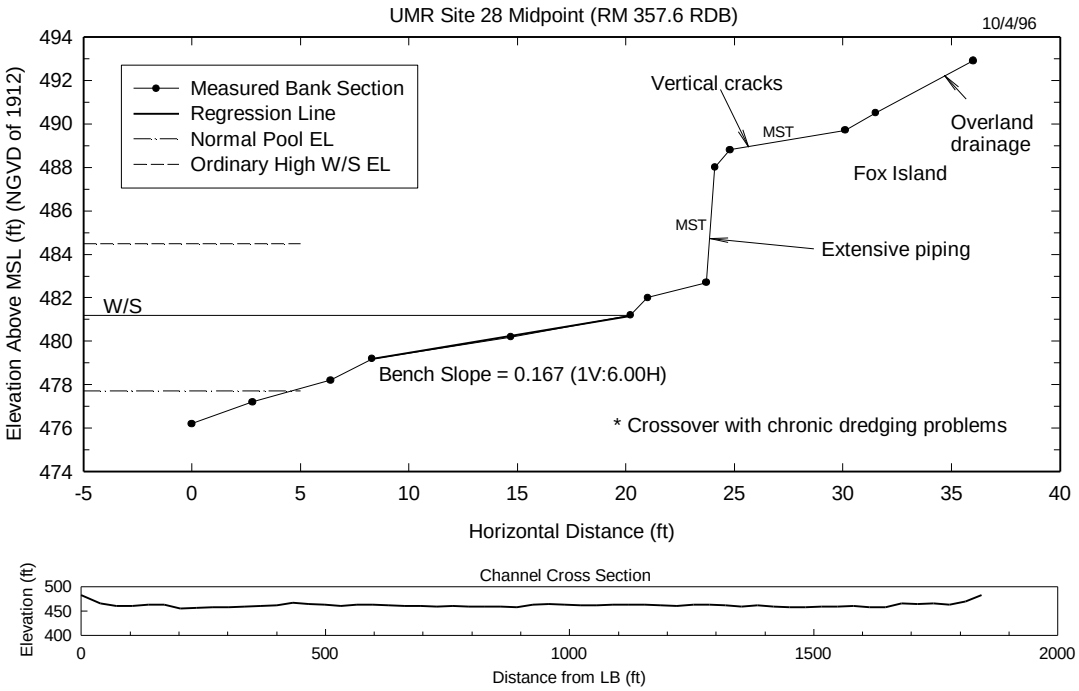

Figure 7-100 Bank section and channel cross section measured at Site 28 midpoint

shows an upstream view of the site and Photo 7-62 is a close-up of the scarp. Photo 7-63 shows extensive vertical cracks associated with block failures along the bank face, and Photo 7-64 shows piping features and vertical cracks. Shown in figure 7-100 is the bank section obtained at this erosion site. The river cross section shown in figure 7-100 has a typical shape for a crossover reach characterized by a nearly constant depth across the width. The scarp, about 7 ft high, is nearly vertical, and the bank soils are predominantly MST.

A MR reach (RM 355 - RM 356) along Fox Island Bar just downstream from Site 28 and a downstream reach around Buzzard Island (RM 349 - RM350) were investigated by Iowa Institute of Hydraulic Research (IIHR), The University of Iowa, in 1976 and 1978. Those studies focused on sediment-transport characteristics around crossovers by both field studies and numerical methods. These reaches required extensive channel dredging. The studies identified significant reduction in the main-channel sediment transport capacity by bifurcations surrounding the study sites (Nakato & Kennedy 1977, Nakato et al. 1979, Nakato & Vadnal 1981).